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WAX RECONSTRUCTION OF THE BRAIN OF AN EMBRYO LIZARD, EUMECES, ... *Clarence L. Turner.*

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Wax Reconstruction of Brain of an Embryo Lizard (*Eumeces.*)

BY CLARENCE L. TURNER.

Plates XXVIII-XXXI.

[Contribution from the Zoölogical Laboratory No. 211.]

INTRODUCTION.

THIS investigation was done with a view to comparing the general features of an embryonic brain with those of an adult lizard brain. The dissection of so small a brain was impractical, so the reconstruction method was used. No attempt was made to study the brain in connection with the skull and the other structures, although considerable information was gathered concerning them during the course of the work. The brain, with the cranial nerves and other appending structures, has been studied by itself, especial attention being given to the shape and relative position of the different lobes, the character of the cavities, the points of attachment, and to some degree the extent of the cranial nerves and to the changes in shape and position of parts that must occur between this stage and the adult stage of the brain.

The work was begun at the Ohio Wesleyan University during the year of 1912-'13, under the supervision of Prof. E. L. Rice of that university, and completed in the University of Kansas.

MATERIALS AND METHOD.

A set of slides kindly loaned by Doctor Rice furnished the material for the work. The slides contained a complete series of sections of the head of an *Eumeces* embryo, which had the following measurements: From tip of snout to posterior end

of tympanum, 4.75 mm. From posterior end of tympanum to anterior end of shoulder, 2.25 mm. From anterior end of shoulder to anus, 7.50 mm. From anus to tip of tail, 13.50 mm.

The embryo had been fixed in picro-acetic acid and the sections stained with Mallory's triple connective tissue stain which brought out the brain and nerves as purple against the red, orange and blue of the other tissues.

The model was constructed according to the directions of Karl Peter in his "die Methoden der Rekonstruktion." The method is briefly as follows: Projections are made of each consecutive section by means of the stereoscope and outline drawings made of the parts to be reconstructed. The magnification is governed by the distance between the stereoscope and the screen upon which the drawings are made. In this particular piece of work a magnification of fifty diameters was used. Wax plates are next prepared, the drawings being fixed to them while the wax is still hot. The proper thickness of the plates is obtained by multiplying the actual length of the object to be reconstructed by the magnification and dividing the result by the number of sections contained in the series. Brass strips of the correct thickness are placed upon a smooth surface, the liquid wax poured upon the surface between them and a hot roller applied to the cooling wax, which is pressed out to the thickness of the strips. The plates are then cut along the lines of the drawings and are placed upon each other to form the model. In order to facilitate the building process a guide line is used. This line is introduced into the paraffin block by painting with lampblack one surface parallel to the object to be sectioned and recoating with a thin coat of paraffin. Cross sections of the tissue will then contain also cross sections of this painted surface in a constant relation to the tissue.

GENERAL TOPOGRAPHY OF BRAIN.

The plates and their explanations illustrate nearly all the points intended to be brought out, so the discussion of them will be brief. The slender olfactory lobes (A) extend posteriorly and unite with the larger cerebral lobes (B) by the olfactory peduncle.

Immediately beneath the cerebral lobes is the median optic thalami (C). At the base of the anterior margin of the optic thalami is the infundibulum (Inf), which appears as a small

lobe separated from the optic thalami by a shallow constriction. The hypophysis is situated directly beneath the infundibulum, and in this stage its diameter is about half of that of the infundibulum. The pineal apparatus (H) is attached to the optic thalami between the lobes of the cerebrum and extends backward and upward from the point of attachment, lying at an angle of about thirty degrees from the horizontal plane. The parietal eye lies just above the posterior end of the pineal body.

The optic lobes (D) lie at an angle of about thirty-five degrees from the horizontal and are connected anteriorly to the optic thalami and ventrally and anteriorly to the medulla. A shallow vertical groove traverses the optic thalami at its posterior end and roughly separates it from the optic lobes.

The cerebellum (E) is relatively very small. It occurs as a median lobe at the base of the optic lobes with its long axis approximately parallel to the axis of the optic lobes.

The medulla (F) occurs directly under the division between the optic thalami and the optic lobes. It extends forward for a short distance, and then turning sharply backward it makes a U-shaped loop. The ventral horn of the loop unites posteriorly with the spinal cord (G), which bends sharply downward. Between the horns of the loop is the forward extension of the cerebellum.

CAVITIES OF THE BRAIN.

The cavities of the olfactory lobes (olfactory ventricles) appear as mere slits which twist spirally through an angle of nearly 180 degrees between their anterior end and the olfactory peduncle.

The cavities within the peduncles themselves are represented by mere lines, the walls lying in apposition.

The cavities of the cerebral lobes (first and second ventricles) are also represented for the most part as curved slits, there being very little actual free space between the walls. Fig. 7 shows the real nature of the cavities, while fig. 9 shows their vertical and fig. 8 their horizontal limits. The cerebral cavities connect with the cavity of the optic thalami through paired openings called the foramen of Monro. The opening is surrounded and partially filled by a plexus of slender, fingerlike processes.

The third ventricle is a thin vertical slit in the middle of the optic thalami. (Fig. 6, 3V.) It extends ventrally into the

infundibulum and posteriorly into the optic lobes. A slender cavity also extends back into the pineal region. (Fig. 10.) The walls of the optic thalami are relatively thick.

The optic ventricles are continuations of the third ventricle into the optic lobes. They correspond in shape to the rounded external lines of the optic lobes.

The cavity occupying the medulla, the fourth ventricle (fig. 9, 4V), is joined dorsally to the union of the third and optic ventricles. A plexus extends into it from the base of the cerebellum and from the side walls, partially dividing it from the cavity of the cerebellum. (Fig. 9, P; fig. 5, P.) The posterior wall of the cerebellum is extremely thin, and it seems that a great deal of readjustment takes place at this point as the embryo passes into the adult condition.

At the base of the cerebellum the fourth ventricle opens to the exterior in the fossa rhomboidalis. (Fig. 9, I; fig 5, I.) The spinal canal joins the posterior end of the fourth ventricle.

The cavity of the hypophysis is horizontally disk-shaped, and in this stage is not connected with the main cavity of the brain.

The pineal apparatus also contains a cavity which does not connect with the main cavity of the brain. It is peculiar in having a very irregular shape and in possessing a number of blind pockets, which may be seen in the diagrams of both the vertical and horizontal planes.

CRANIAL NERVES.

The cranial nerves with their points of attachment and their extensions as far as modeled are shown in the plates, so that little more need be said concerning them.

The crossing of the nerve tracts in the optic chiasma is shown in a series of drawings (fig. 12) and a diagram representing the mode of crossing of the nerves is also represented (fig. 13). The chiasma of *Eumeces* is almost identical in its mode of crossing with *Lacerta,* the European lizard.

COMPARISON OF THE ADULT AND EMBRYONIC BRAIN.

A glance at the shape of the embryonic brain shows that a great many changes must take place in its shape as well as in its size before it reaches the adult condition. (Figs. 14 and 15.) The most evident changes are shown in fig. 15 by arrows. The tendency of the whole brain is to assume a longer axis.

The optic thalami shows a tendency to elongate anteriorly. The hypophysis is pulled back from a position directly beneath the infundibulum until it assumes a position behind and a level with the infundibulum.

The point of attachment of the sixth cranial nerve serves as an excellent mark to follow in tracing the change of position of the medulla. In the development to the adult stage the loop in the medulla becomes straightened out and the point of attachment of the sixth cranial nerve is pulled back from a position beneath the optic thalami to occupy one posterior to the optic lobes.

The spinal cord comes to lie in a horizontal plane, whereas in the embryo it bends sharply downward from its junction with the brain.

The cerebellum, which in the embryo is small and undeveloped and appears "pinched" between the optic lobes and the spinal cord, develops and takes a dorsal rather than a posterior position in reference to the rest of the brain.

The pineal apparatus extends forward from its attachment in the adult stage, while in the embryonic stage its extends backward. From the stage modeled to the adult stage it must revolve forward through an angle of about 110 degrees.